JOURNAL OF VETERINARY MEDICAL RESEARCH 2017, 24 (2): 266-276

Journal homepage:
http://www.bsu.edu.eg/bsujournals/JVMR.aspx

Online ISSN: 2357-0520 Print ISSN: 2357-0512

Original Research Article

Negative Impact of Metritis and Endometritis on Reproductive Performance in Dairy Cattle

Hussein, M.M; Goma, A; Abdel –Halim, B.R. and Saber, M. Abdallah

Department of Theriogenology, Faculty of Veterinary Medicine, Beni Suef University

ABSTRACT

The current study was conducted to investigate the incidence of metritis and endometritis in dairy cows. Moreover, to determine the collective impact of metritis and endometritis in dairy farms on reproductive performance and milk yield. A total number of 246 Holstein cows divided into three groups was included in the current study.One of these groups as control group and the second and the third groups were including those cows diagnosed with acute postpartum metritis and chronic endometritis, respectively. The obtained results showed that endometritis possessed severe negative effects on postpartum reproductive performance of the studied cows compared to normal cows. Moreover, the impact of this disease was higher in premiparous cows in comparison with com their pleuriparous herd-mates. Days to first estrus tended (P=0.06) to be increased in premiparous cows suffering from endometritis (89.19±12.12 days) compared to normal cows (59.45±3.30 days) or those suffering from acute metritis (65.37±4.92 days). While in pleuriparous cows, the negative effects of endometritis did not show any tendency for prolonged days to first estrus, when compared to normal cows. Endometritis had significantly (P<0.01) negative impacts on postpartum cyclicity in premiparous cows (89.19±12.12 days), compared to 56.32±3.15 days in pleuriparous cows. Endometritis, significantly negatively (P<0.05) impacted days to first AI in both premiparous cows (105.63±12.95 days, compared to 65.97±2.63 days for normal cows and pleuriparous cows (76.19±3.64 days). A nearly similar trend was observed for endometritis and metritis regarding their potential negative impacts on number of inseminations per conception in both premiparous and pleuriparous cows. Regarding to, days open, diseases like endometritis was associated with significantly (P<0.01) higher days open in both premiparous and pleuriparous cows. Meanwhile, advancing parity was associated with significantly (P<0.05) higher days open for cows suffering from endometritis only.

***Corresponding author**. *Department of Theriogenology*, Faculty of Veterinary Medicine, Beni Suef University. Tel: 01007111266

ARTICLE INFO :

Article history:

Received 11/2017

Accepted 12/2017

Online : 12/2017

Keywords:

Metritis, Reproductive performance, Dairy cattle

Introduction

Several physiological changes occur in the cow's uterus soon after calving. These changes are significant if a cow is to recover and come back into season, ready to conceive, thus any factors that interfere with the normal functioning of the uterus and other associated structures will affect overall reproductive performance(Onyango, 2014).Postpartum uterine infection is represented one of the main factors affecting on the aforementioned physiological changes (Sheldon and Dobson, 2004).

Despite a lack of precision and variations among research groups, the definitions of uterine infections encountered in cattle have been extensively reviewed and expressed (Foldi et al., 2006; Palenik et al., 2009; Potter et al., 2010). Whilst it is not always possible to group every animal with uterine infection, some definitions have been used. Puerperal metritis can be defined as an acute systematic illness due to infection of the uterus by pathogenic bacteria, usually within 10 days after parturition (Sheldon and Dobson, 2004 andWilliams et al., 2008).

Uterine infections have a negative impact on animal welfare and reproductive performance, and lead to major economic losses (Sheldon, 2004). The incidence of clinical metritis in cows and heifers has been reported as 18.6% and 30%, respectively (Williams et al, 2005). Sheldon et al.(2006) have determined the incidence of clinical metritis during the first two weeks of the postpartum period as 25-40%. It has been indicated that the incidence of clinical metritis at herd level ranges between 5% and 26%, and is on average 17% (Ghanem et al, 2002). Furthermore, the incidence of subclinical endometritis has been reported to range from 19% to 74%, and to be 53% on average (Gilbert et al, 2005 and Plöntzke et al, 2010). The large differences observed between the incidences determined in previous studies have been attributed to the diagnostic methods employed, the method used for the classification of uterine infections, the postpartum period in which the uterine infection was diagnosed, the general traits of the bovine animals included in previous research, their parity, and the management of the herds included in previous studies (Azawi, 2008).

The exact risk factors associated with postpartum uterine infections in cows are unknown. However, several investigations have identified some of the risk factors and found that they vary among different regions or countries because of the differences in general management, environment and herd health conditions (Kim and Kang, 2003; Bell and Roberts, 2007; Potter et al., 2010). Various risk factors related to management and individual cows have been identified. They include retained fetal membranes (Abdelhameed et al., 2009), dystocia (Garry, 2004), age (Sheldon et al., 2006), parity (Gautam et al., 2009) calving season (Buckley et al., 2010), breed (Potter et al., 2010) and nutrition (Bell and Roberts, 2007) among others.

It has been estimated that for every 100 cows served for the first time, only about 30% live births occur, suggesting that uterine infection is one of the leading causes of reduced fertility in many dairy herds (Dobson et al., 2007). LeBlanc (2002) found that conception rate was 20% lower in cows with endometritis, with a median calving to conception interval of 30 days longer and that about 35% more animals were culled for failure to conceive. Similarly, McDougall et al. 2011) and Lee and Kim (2006) showed increased culling and reduced pregnancy rates in cows with uterine infection while Gilbert et al. (2005) found endometritis was highly significant for reduced pregnancy rates where days open was 218 and 118, first service pregnancy rate 11% and 36% and pregnancy until day 300 postpartum 63% and 89% in cows with or without uterine infection respectively in a sample of dairy herd in the US. Gautam et al. (2009) found that clinical endometritis diagnosed in the late postpartum

period (29-60 days) decreased pregnancy rate. Bell and Roberts (2007) reported that uterine infection can have a great impact on dairy cow health and welfare and the subsequent reproductive performance. Sheldon and Dobson (2004) highlighted that the financial losses associated with uterine infections are dependent on the reduced milk yield, cost of treatment and subfertility. It was estimated that a worldwide significant loss of 2.5 billion Euros per annum on the dairy industry was due to postpartum uterine infections (LeBlanc et al., 2002).

The objective of the study was to identify, at the lactation level, the postpartum risk of uterine infection on time to first estrus, number of inseminations per conception and days open in a commercial dairy herd.

Material and Methods:

The present study was conducted on 246 Holstein cows belonging to El- Lahamy Dairy Farm which is located in El Fayoum Governorate. Those animals were divided into 3 groups:

The 1st group of 99 normal cows of which 33 premiparous and 66 pleuriparous cows as control group.

The second group of 78 cows (38 premiparous and 40 pleuriparous) were diagnosed with acute postpartum metritis within 15 days postpartum.

The 3rd group of 69 cows (16 premiparous and 53 pleuriparous) and were diagnosed with chronic endometritis.

All cows were raised in an open yard system with a muddy land and were fed TMR according NRC, 2001. Cows were milked three times a day and were distributed in yards according productive and reproductive status. Dairy Life program was used for recording system and all events were recorded on daily basis. Fresh cows (recently calved cows till 28 days postpartum) were raised in a separate yard to follow up specially for checking up postpartum metabolic disorders, retained fetal membranes and uterine infection. Rectal temperature was recorded for those animals for 10 days postpartum and fecal score was done by herd manager on daily basis for these animals. The diagnosis of acute postpartum metritis was depending on the clinical signs which were mainly systemic including high temperature (> 39.5 C), off feed, putrid uterine discharge, low milk production and abnormal attitude. Diagnosis of chronic endometritis was depending on observation of abnormal uterine discharge at laying or at estrus phase, or during routine rectal examinations and ultrasonography. Treatment of acute postpartum metritis was mainly depending on systemic treatment. Treatment of endometritis was mainly depending on injection of PGF2α and in many cases with intrauterine antibiotics.

Reproductive management:

Estrus detection was performed by herdsmen and milking employees via visual observations and artificial insemination was done on AM and PM basis. Pre-Synch, Ov-Synch and Re-Synch programs were performed routinely in the farm. Pr-synch program was performed specially for those cows diagnosed with endometritis for cleaning up of cows.

Statistical analysis:

Statistical analyses were performed using **SPSS (2013).** Pearson's correlation coefficient of factors was used to compare results between variables. All data are presented as means ± SEM. The results were found to be significant when $P<0.05$.

Results:

As shown in table 1, it was clear that Endometritis possessed severe negative effects on postpartum reproductive performance of the studied cows compared to normal cows. Moreover, the impact of this disorder was higher in premiparous cows, compared to their herd mates of pleuriparous. Days to first estrus tended ($P=0.06$) to be increased in premiparous cows suffering from endometritis (89.19±12.12

days) compared to normal cows (59.45±3.30 days) or those suffering from metritis (65.37±4.92 days). Endometritis, significantly induced a negative (P<0.05) impact on days to first insemination in both premiparous cows (105.63±12.95 days) and pleuriparous cows (76.19±3.64 days) in comparison with normal cows. A nearly similar trend was observed for metritis and endometritis regarding their potential negative impacts on number of inseminations per conception in both premiparous and pleuriparous cows. Regarding days open, diseases like endometritis was associated with significantly (P<0.01) higher days open in both premiparous and pleuriparous cows. Meanwhile, advancing parity was associated with significantly (P<0.05)higher days open for cows suffering from endometritis only.

Table 1: The effects of acute postpartum metritis and chronic endometritis on fertility indices.

	Days to first estrus		Days to first AI		NIPC		Days open	
	Premiparous	Pleuriparous	Premiparous	Pleuriparous	Premiparous	Pleuriparous	Premiparous	Pleuriparous
Control (33 vs. 66)	59.45±3.30[a]	53.86±2.17	65.97±2.63[a]	66.61±1.44[a]	1.94±0.26[a]	2.44±0.19[a]	109.40±12.59[a]	111.79±5.86[a]
Metritis (38 vs. 40)	65.37±4.92[a]	57.13±2.86	81.24[ab]±5.83[ab]	75.25±3.93[ab]	3.20±0.39[ab]	4.25±0.58[b]	165.45±16.14[ab]	175.40±16.59[b]
Endometritis (16 vs. 53)	89.19±12.12[b]	56.32±3.15	105.63±12.95[b]	76.19±3.64[b]	4.06±0.84[b]	3.34±0.34[ab]	210.88±21.84[b]	156.70±11.61[b]
P value	0.06	0.37	0.03	0.02	0.03	0.01	<0.01	<0.01

AI: Artificial insemination; NIPC: number of inseminations per conception

Values are expressed as means ± SE.

Means within the same column with different alphabetical are significantly differ at P< 0.01

Pearson's correlation coefficients (r) between production parameters and reproductive problems in Holstein cows.

The most prominent result was a significantly negative correlation between metritis and 305 day milk yield as shown in table 2 (r=-0.10, P<0.05).

Table (2): Pearson's correlation coefficient (r) between production parameters and reproductive problems in studied Holstein cows.

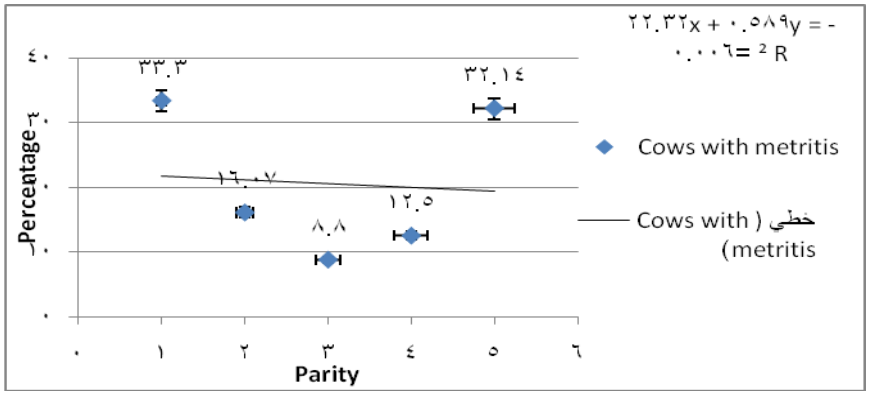
	Metritis	Endometritis
Peak milk	-0.08	-0.06
Peak day	0.05	-0.01
100 day milk	-0.06	-0.03
305 day milk	-0.10*	0.03

* Significant correlation at P<0.05.

3.6. Relationship between parity and incidence of Metritis in Holstein cows.

Metritis in the present work did not show any association with parity in Holstein cows (R^2=0.006). According to figure 3, the incidence of Metritis was 33.3% in first lactation cows, reached a minimum of 8.8%in third parity cows and increased to 32.14% in the fifth parity cows.

Figure (1): Incidence of metritis according to parity in Holstein cows:

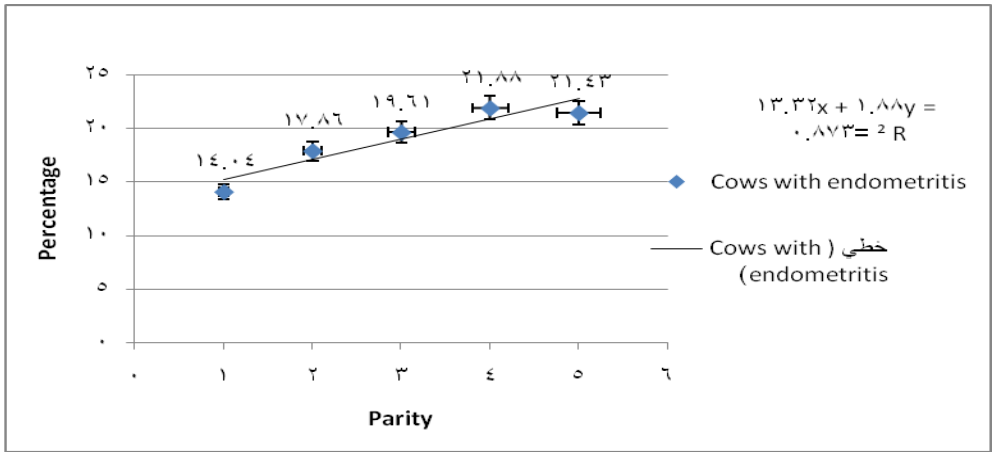


Relationship between parity and incidence of endometritis in Holstein cows.

As depicted in figure 1, it was clear that incidence of endometritis was increased with advancing parity in the current study varying from 14.04% for premiparous cows to 21.88% for 4th lactation cows. Interestingly, all points were so close to the slope of the regression line (R^2=0.87). The slope of the

equation was a one point increase in parity was associated with a 1.88 points increase in the incidence of endometritis.

Figure (2): Incidence of endometritis according to parity in Holstein cows



Discussion

Endometritis dramatically impairs the reproductive performance of high yielding dairy cows due to persistent bacterial infection, which leads to inflammation and damage to the endometrium thereby, prolonging uterine involution and impairing fertility **(Fourichon et al., 2000 and Kasimanickam et al., 2004).** The obtained results showed that endometritis possessed severe negative effects on postpartum reproductive performance of studied cows compared to normal cows. Moreover, the impact of this disease was higher in premiparous cows, compared to their pleuriparous herd-mates. Our results came in agreement with **Miller et al. (1980)** who found that, the diagnosis of endometritis by rectal palpation or by observation of a genital discharge is insensitive and non-specific and support the results of **Földi et al. (2006)** and finding of **Palmer (2008)** who reported that, diagnosis of clinical endometritis using palpation per-rectum is subjective, not effective and prone to error as it lacks standardization. In pleuriparous cows had a greater tendency to accumulate fluid in their uterus than premiparous cows. Moreover, **Lee and Kim (2006)** reported that, parity increases milk yield, body condition loss during early lactation, the risk of periparturient disorders, and culling due to reproductive failure in dairy herds. In addition, the prevalence of subclinical endometritis has been reported to be similar in premiparous and pleuriparous cows **(Cheong et al., 2011).** Furthermore, a high milk production and the parity showed associations with an excessive body condition score loss **(Tsousis et al., 2009).** Some studies found that parity is another factor that affects conception rates **(Kaufmann et al., 2009)** or the chance of insemination and pregnancy **(Pleticha et al., 2009)** while others did not **(Lincke et al., 2006).** Although published results have varied, either high or low BCS has also been related to greater incidences of metritis, retained placenta, milk fever, lameness, cystic ovaries, dystocia, displaced abomasum, and mastitis. **Titterton**

and Weaver (1999) observed higher uterine discharge scores for cows calving with BCS ≤3.25 (US BCS) or ≥4.25 (US BCS) than for cows calving with BCS of 3.0. On the contrary, to our results **Kadivar et al. (2014)** concluded that, low BCS is a risk factor for postpartum endometritis and delayed cyclicity in dairy cows. Moreover **Heuer et al. (1999)** reported that endometritis occurred after 20 days postpartum in thin cows. Furthermore it has been reported that, cows with BCS at calving <3.0 were more likely to have metritis than cows with a higher BCS at calving **Markusfeld et al. (1997)** demonstrated that cows losing more BCS during the dry period were more likely to experience metritis. In addition **Kasimanickam et al. (2013)** reported that, cows with metritis or clinical endometritis had lower or lost body condition compared to those with subclinical endometritis or normal cows. Meanwhile, **Waltner et al. (1993)** failed to identify a relationship between BCS and metritis. BCS has previously been reported as a risk factor for subclinical endometritis in pasture-grazed cows **(McDougall et al. 2011)** increased body fat mobilization, as evidenced by elevated NEFA concentrations, was associated with an increased risk of metritis **(Duffield et al. 2009).** In our results, days to first estrus tended (P=0.06) to be increased in premiparous cows suffering from endometritis (89.19±12.12 days) compared to normal cows (59.45±3.30 days) or those suffering from Metritis (65.37±4.92 days). While in pleuriparous cows, the negative effects of endometritis did not show any tendency for prolonged days to first estrus, when compared to normal cows. There may be an antagonistic relationship between milk yield and reproductive performance **(Butler and Smith, 1989).** However, **Shanks et al. (1979)** suggested that high yielding cows might be more reproductively sound because they are healthier than are lower yielding cows. Loss of milk production appears to be confined to those individuals that progress to clinical metritis**(Fourichon et al., 2000).** Premiparous cows that produced more milk had increased odds of having subclinical endometritis, whereas pleuriparous cows that produced more milk had decreased odds of having subclinical endometriti**s (Cheong et al., 2011).** Subclinical endometritis is likely the result of impaired uterine immune function due to negative energy balance and a mechanism of energy balance affecting reproduction. The interaction between milk production and parity was strongly associated with the risk of subclinical endometritis. We do not have an explanation for this finding, but it could be due to the difference in experimental design, production system, feeding regime. **LeBlanc et al. (2002)** reported that cows with muco-purulent or worse uterine discharge that persisted beyond 60 DIM had a more pronounced reduction in pregnancy rate than cows with endometritis diagnosed < 60 DIM. In our study, endometritis, significantly negatively (P<0.05) impacted days to first AI in both premiparous cows (105.63±12.95 days, compared to 65.97±2.63 days for normal cows and pleuriparous cows (76.19±3.64 days), compared to 66.61±1.44, days for normal cows. A nearly similar trend was observed for endometritis and metritis regarding their potential negative impacts on number of inseminations per conception in both premiparous and pleuriparous cows. Regarding to, days open, diseases like endometritis was associated with significantly (P<0.01) higher days open in both premiparous and pleuriparous cows. Meanwhile, advancing parity was associated with significantly (P<0.05) higher days open for cows suffering from endometritis only.

References:

Abdelhameed AR, Ahmed WM, Ekhnawy KI and Khadrawi HH (2009). Strategy trials for prevention of retained foetal membranes in a Friesian herd in Egypt. GlobalVeterinaria, 3: 63-68.

Bell MJ and Roberts DJ (2007). The impact of uterine infection on a dairy cow's performance. Theriogenology,68: 1074-1079

Buckley F, Dillon P and Mee JF (2010). Major management factors associated with the variation in the reproductive performance in Irish dairy herds. Final Report Project 5070. http://www.agresearch.teagasc.ie/moore par. [Accessed 11/05/2013].

Butler W.R. and Smith R.D. (1989): Interrelationships between energy balance and postpartum reproductive function in dairy cattle. J Dairy Sci.;72 (3):767-83. Review.

Butler, W.R. (2003): Energy balance relationships with follicular development, ovulation and fertility in postpartum dairy cows. Livest. Prod. Sci.83: 211-218.

Cheong, S.H.; Nydam, D.V.; Galvão, K.N.; Crosier, B.M. and Gilbert, R.O.. (2011): Cow-level and Herd-level Risk Factors for Subclinical Endometritis in Lactating Holstein Cows." J. Dairy Sci. 94:762-770.

Dobson, H. Tebble, J.E. and Phogat, J.B, (2007): Smith RF. Effect of transport on pulsatile and surge secretion of LH in ewes in the breeding season. J ReprodFertil. 19May;116 (1):1-8.

DUFFIELD, T. F.; LISSEMORE, K. D.; MCBRIDE, B. W. AND LESLIE, K. E. (2009): Impact of hyperketonemia in early lactation dairy cows on health and production. J Dairy Sci 92(2):571- 580.

Foldi J, Kulksar M, Pecsi A and Lohuis JACM (2006). Bacterial complications of postpartum uterine involution in cattle. Animal Reproduction Science, 96: 265-281

FOURICHON, C.; SEEGERS, H. AND MALHER, X., (2000). Effect of disease on reproduction in the dairy cow: a meta-analysis. Theriogenology 53, 1729–1759.

Garry FB (2004). An overview of animal welfare in the US dairy industry. Bovine Practice, 38: 1-22.

Gautam G, Nakao T, Yusuf M and Koike K (2009).Prevalence of endometritis during postpartum period and its impact on subsequent reproductive performance in two Japanese dairy herds.Animal Reproduction Science, 116: 175-187.

Ghanem M, Shalaby AH, Sharawy S, Saleh N (2004): Factors leading to endometritis in dairy cows in Egypt with special reference to reproductive performance. J ReprodDev, 48, 371-375, 2002.

Gilbert RO, Shin ST, Guard CL, Erb HN, Frajblat M (2005): Prevalence of endometritis and its effects on reproductive performance of dairy cows. Theriogenology, 64, 1879-1888, 2005.

GROENENDAAL, H.; GALLIGAN, D.T. AND MULDER H.A. (2004): An economic spreadsheet model to determine optimal breeding and replacement decisions for dairy cattle. J. Dairy Sci; 87: 2146-2157.

Heuer, C., Schukken, Y.H. and Dobbelaar, P., (1999): Postpartum body condition score and results from the first test day milk as predictors of disease, fertility, yield, and

culling in commercial dairy herds, Journal of Dairy Science, 82, 295–304.

Kadivar, A.; Ahmadi, M.R. and Vatankhah, M. (2014): Associations of prepartum body condition score with occurrence of clinical endometritis and resumption of postpartum ovarian activity in dairy cattle. Trop Anim Health Prod. Jan;46 (1):121-126.

KASIMANICKAM, R., DUFFIELD, T.F., FOSTER, R.A, GARTLEY, C.J, LESLIE, AND K.E; WALTON, J.S AND JOHNSON W.H. (2004): Endometrial cytology and ultrasonography for the detection of subclinical endometritis in postpartum dairy cows. Theriogenology; 62: 9-23.

Kasimanickam, R.K.; Kasimanickam, V.R.; Olsen, J.R.; Jeffress, E.J.; Moore, D.A. and Kastelic, J.P. (2013): Associations among serum pro- and anti-inflammatory cytokines, metabolic mediators, body condition, and uterine disease in postpartum dairy cows. ReprodBiolEndocrinol. Nov 9; 11:103.

KAUFMANN, T. B., DRILLICH, M.; TENHAGEN, B. A.; FORDERUNG, D. AND HEUWIESER, W. (2009):Prevalence of bovine subclinical endometritis 4h after insemination and its effects on first service conception rate. Theriogenology 71 (2):385-391.

Kim IH and Kang H (2003). Risk factors for postpartum endometritis and effect of endometritis on reproductive performance in dairy cows in Korea. Journal of Reproduction and Development, 49: 485491.

LEBLANC, S.J., DUFFIELD, T.F., LESLIE, K.E., BATEMAN, K.G., KEEFE, G.P., WALTON, J.S. AND JOHNSON, W.H.(2002):The effect of treatment of clinical endometritis on reproductive performance in dairy cows. J Dairy Sci; 85: 2237-2249.

Lee, J.Y. and Kim, I.H. (2006): Advancing parity is associated with high milk production at the cost of body condition and increased periparturient disorders in dairy herds. J Vet Sci, 7, 161-166.

LEWIS, G.S. (2003): Steroidal regulation of uterine resistance to bacterial infection in livestock. Repro BiolEndocrinol; 1: 117.

LINCKE, A., DRILLICH, M., HEUWIESER, W., (2006): Subclinical endometritis in dairy cattle and its effect on reproductive performance - a review on recent publications. BerlMünchtierarztlWschrift 120, 245-250.

Markusfeld, O., Galon, N. and Ezra, E. (1997): Body condition score, health, yield and fertility in dairy cows. Vet Rec.19; 141(3):67-72.

McDougall, S., Hussein, H., Aberdein, D., Buckle, K., Roche, J., Burke, C., Mitchell, M. and Meier, S. (2011): Relationships between cytology, bacteriology and vaginal discharge scores and reproductive performance in dairy cattle. Theriogenology.15;76 (2):229-240.

MILLER, H. V., KIMSEY, P. B. and KENDRICK, J. W. (1980): Endometritis of dairy cattle: diagnosis, treatment, and fertility. Bovine Practitioner 15, 13-23.

Onyango, 2014: A review of reproductive performance of female BosIndicus (Zebu) cattle...http://www.fao.org/wairdocs/ilri/x5442e/x5442e02.htm#TopOfPage

Palenik T, Dolenzel R, Kratochvil J, Cech S, Zajik J, Jan Z and Vyskocil M (2009). Evaluation of rectal temperature in diagnosis of puerperal metritis in dairy cows.Veterinary Medicine, 54: 149-155.

PALMER, C.W. (2008): Postpartum endometritis: Current concepts in diagnosis and treatment. 29th World Veterinary Congress: 241-250.

PLETICHA, S., DRILLICH, M. AND HEUWIESER, W., (2009): Evaluation of the Metricheck device and the gloved hand for the diagnosis of clinical endometritis in dairy cows. J Dairy Sci 92, 5429-5435.

Plöntzke J, Madoz LV, De La Sota RL, Drillich M, Heuwieser W (2010): Subclinical endometritis and its impact on reproductive performance in grazing dairy cattle in Argentina. AnimReprodSci, 122, 52-57.

Potter TJ, Guitian J, Fishwick J, Gordon PJ and Sheldon IM (2010). Risk factors for clinical endometritis in postpartum dairy cattle. Theriogenology, 74: 127134.

Shanks, RD., Freeman,V. and Berger, P.J. (1979): Relationship of reproductive factors with interval and rate of conception. Journal of Dairy Science, 62: 74.

Sheldon IM and Dobson H (2004). Postpartum uterine health in cattle.Animal Reproduction Science,82: 295-306.

Sheldon IM, Lewis GS, LeBlanc SJ and Gilbert RO (2006). Defining postpartum uterine disease in cattle. Theriogenology, 65: 1516-1530.

Sheldon IM, Williams EJ, Miller ANA, Nash DM, Herath S (2008): Uterine diseases in cattle after parturition. Vet J, 176, 115-121.

Sheldon IM (2004): The postpartum uterus. Vet Clin North Am: Food AnimPract, 20, 569-591.

SHELDON, I.M., BUSHNELL, M., MONTGOMERY, J. AND RYCROFT, A.N., (2004): Minimum nhibitory concentrations of some antimicrobial drugs against bacteria causing uterine infections in cattle. Vet Rec 155, 383-387.

SPSS (2013): Statistics for windows version 22.0.Armonk, NY:IBM corp.

Titterton, M., and Weaver, L. D. (1999): The relationship between body condition at calving, uterine performance postpartum and trends in selected blood metabolites postpartum in high yielding Californian dairy cows. p. 335 in Fertility in the High-Producing Dairy Cow. Occas. Publ. No. 26. Br. Soc. Anim. Sci., Edinburgh, UK.

Tsousis, G., Sharifi, R. and Hoedemaker, M. (2009): Associations between the clinical signs of chronic endometritis with ovarian cysts and body condition loss in German Holstein Friesian cows. J Vet Sci. Dec; 10(4):337-341.

Waltner, S. S., McNamara, J. P. and Hillers, J. K. (1993): Relationships of body condition score to production variables in high producing Holstein dairy cows. J. Dairy Sci. 76:3410–3419.

Williams EJ, Fischer DP, Pfeiffer DU, England GCW, Noakes DE, Dobson H, Sheldon IM (2005): Clinical evaluation of postpartum vaginal mucus reflects uterine bacterial infection and the immune response in cattle. Theriogenology, 63, 102-117.

Williams EJ, Herath S, England GCW, Dobson H, Bryant CE and Sheldon IM (2008). Effect of Escherichia coli infection of the bovine uterus from the whole animal to the cell. Animal Consortium, 2: 11531157.